Fission Neutron Multiplicity Functions for Preinitiation Calculations

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The vast majority of the world's plutonium (Pu) comes in the form of reactor-grade Pu as opposed to weapons-grade Pu. For this reason, the threat of a nuclear attack on the U.S. from a device based on reactor-grade Pu must be taken very seriously. The most important difference between weapons-grade and reactor-grade fuel is the high content of ^{240}Pu in the latter. Plutonium-240 has a high spontaneous fission rate and this in turn leads to a greatly increased probability of device preinitiation. In this project we have been examining the fission neutron multiplicities associated with spontaneous fission of the Pu isotopes found in reactor-grade Pu.

The probability of obtaining a divergent fission chain from a neutron emitted in spontaneous fission depends on neutron multiplicity probabilities $p(n)$. The neutron multiplicity probabilities determine the probability of obtaining n neutrons given that the average number of neutrons emitted per fission is $\bar{\nu}$. In the transport codes used to calculate preinitiation probabilities, these neutron multiplicities appear directly in the total multiplicity functions C_n, which determine the number of ways of obtaining n neutrons given $\bar{\nu}$. The neutron multiplicity probabilities $p(n)$'s are well described in terms of a Gaussian distribution around the average number, $\bar{\nu}$, as first calculated by Terrell in 1957. Terrell evaluated the available neutron multiplicity data and found that a single Gaussian distribution with a global variance $\sigma = 1.08$ provided a good description of data. However, there have been numerous experiments since then. In the present work we have compiled all the data measured since the mid 1950s and examined whether or not a global variance still satisfactorily describes all experimental data. In doing so, we have obtained improved descriptions of fission neutron multiplicities.

Our analysis of the more modern and expanded data for neutron multiplicities showed that the variance of the Gaussian distribution around the average neutron number increased from Terrell's global value of 1.08 to 1.14 for the Pu isotopes. This in turn implied a 33% increase in the probability of emitting four neutrons from the fission of ^{239}Pu.

We also found that the data sets showed a systematic dependence on the variance, $\bar{\nu}$ which varies with the mass and charge of the nucleus. Our analysis suggests that an overall weighted average for $\bar{\nu}$ is not physically justified. We have proposed that the transport codes be extended to include a nucleus and $\bar{\nu}$ dependent σ. Figure 1 shows how the total multiplicity functions C_n change when such a dependence is used.

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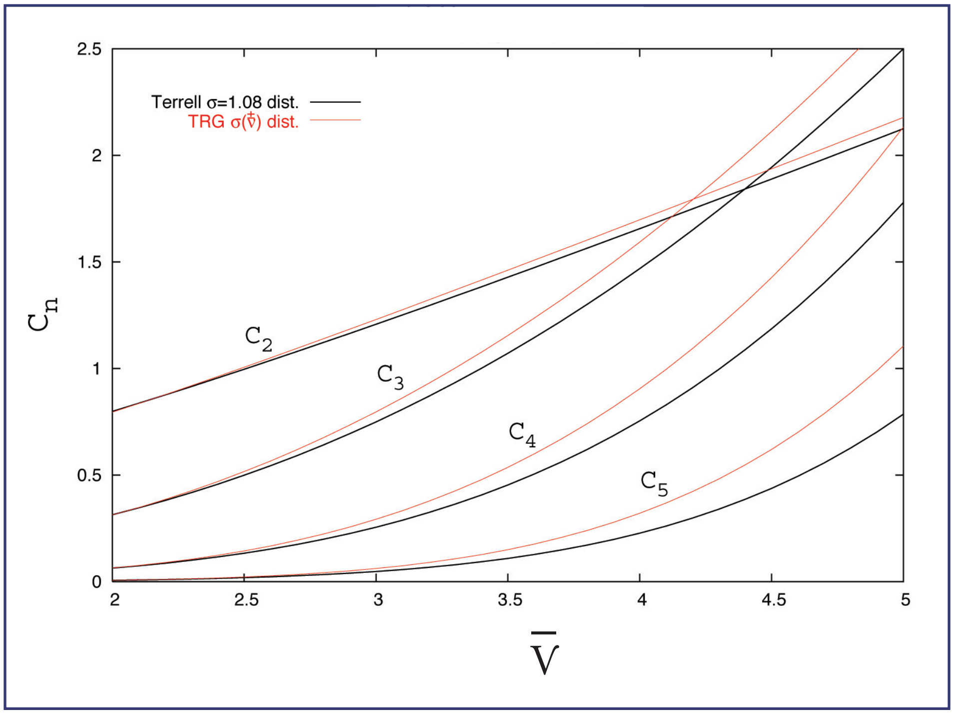

Figure 1—
The figure shows how the total multiplicity functions Cn change.